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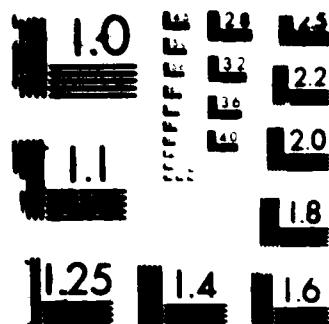
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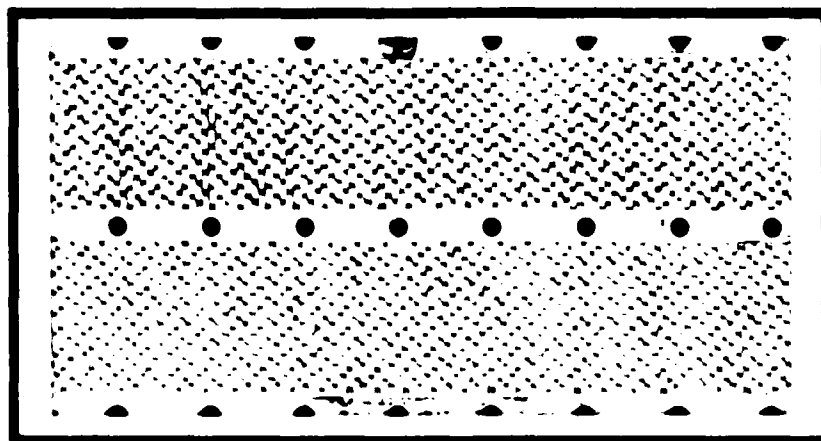
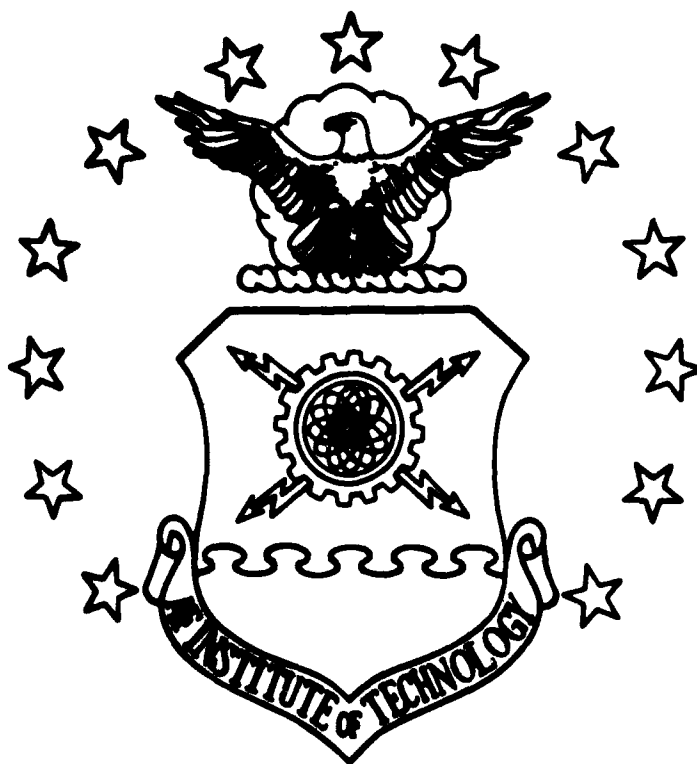
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ENGINE SHOP REQUIREMENTS

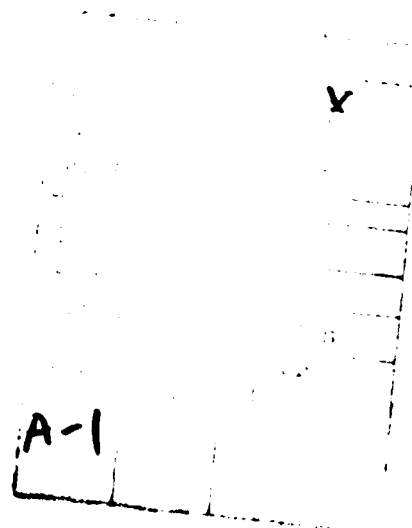
THESIS

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AFIT/GLM/LSM/87S-18

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A COMPOSITE FIGHTER WING STRUCTURED TAF:
ENGINE SHOP REQUIREMENTS

THESIS

Presented to the Faculty of the School of Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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Captain, USAF

September 1987

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Preface

I believe the Air Force must strive to achieve two important goals. First, is the challenge to meet and exceed the war skills of those countries that oppose freedom as we know it in the US. Secondly, we must do this in the face of continuously declining defense budgets. Although these two goals may seem incompatible, they must be sought with equal zeal.

To meet these challenges, we must consider ideas other than newer, faster, and more advanced equipment. I believe that Col Robert Wiswell has offered such an idea by suggesting a new force structure for the IAF. This idea must be evaluated and if proven prudent, put into effect. As part of that evaluation, this study shows the facility and manpower requirements in the propulsion area needed to achieve this new structure.

This thesis effort would not have been possible without the superb support I recieved from others. I would like to thank my thesis advisor LTC Paul Reid who not only suggested this topic, but whose quick mind, patience, and encouragement allowed for a quality report to be produced. I wish to give special acknowledgment to the NCOs at the Propulsion Division at HQ IAC, especially those in the F100 section, because without their help, much of the data and content of this thesis would not have been possible. Finally, I would like to thank my wife Tanya, who tried her best to keep our three daughters preoccupied while I spent numerous hours staring at my computer trying to think of what to write.

Paul A. Davidson

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Abstract

This study focused on the requirements for an engine shop under a composite fighter wing structure. The composite fighter wing structure was proposed to provide Tactical Air Forces the capability to better meet the challenge of low intensity conflicts and to provide increased aircraft survivability. The proposal called for use of three basic wings: Close Air Support, made up of A-10s and F-16s; Interdiction, made up of F-16s and F-15s; and Counter Air, also made up of F-16s and F-15s.

This study looked specifically at engine shop facility sizes, engine test facilities, and engine shop manpower needs. All computations were based on current facility size measurement data, test facility needs, and manpower authorizations. This information was used to calculate the engine shop requirements for each type of composite fighter wing engine shop.

The study revealed that a Close Air Support Wing would require a facility of 28,906 - 39,845 square feet, 3 - 4 engine test facilities, and 85 - 99 engine shop repair personnel. An Interdiction Wing required a facility 31,805 - 65,441 square feet, 3 - 4 test facilities, and 76 - 94 personnel. The Counter Air Wing would need 38,580 - 73,036 square feet of facility space, 3 - 4 test facilities, and 85 - 106 personnel.

A COMPOSITE FIGHTER WING STRUCTURED TAF:
ENGINE SHOP REQUIREMENTS

I. Introduction

General Issue

To support United States (US) national military objectives, the United States Air Force (USAF) must be ready and able to respond to acts of aggression against the US or its friends, without regard to time or place. The USAF must have the capability to conduct operations at various levels of intensity for as long as necessary to achieve the desired political results (12:2). This flexibility is necessary because no conflict or act of aggression is precisely like the one that preceded it. Former USAF Chief of Staff, General Charles A. Gabriel believes, there is an "increasing likelihood that the speed and violence of lower level conflicts, not necessarily involving the Soviet Union or its surrogates, will increase dramatically" (25:80). As the variety and possibility of conflict increases the USAF should continue to search out new ideas that enhance its ability to support US national security.

Recently, one such idea was proposed. Colonel Robert Wiswell, while Director, Tactical Force Structure Directorate, Air Force Logistics Command (AFLC) Logistics Operations Center, recommended that the Tactical Air Forces (TAF) convert to a new fighter wing structure. This structure has become known as the composite fighter wing. The

structure provides for three basic types of fighter wing configurations. The first is the close air support wing made up of two A-10 squadrons and one F-16 squadron, or three A-10 squadrons. The second is the interdiction wing having two F-16 squadrons and one F-15 or F-15E squadron. The third basic type is the counterair wing consisting of two F-15 squadrons and one F-16 squadron, or one F-15 squadron and two F-16 squadrons. It is believed that the composite fighter wing structure is more appropriate for meeting the challenge of conventional warfare and/or low intensity conflicts than our present structure. This structure should also increase aircraft survivability on the ground and effectiveness in the air when there is little or no communications (27:12).

Specific Problem

Despite the operational advantages a composite fighter wing may offer, a composite fighter wing may not be feasible from a logistical viewpoint. Can the Air Force, given its fiscal and manpower authorizations, convert from its present logistic infrastructure into one capable of supporting a composite fighter wing? Due to the immensity of this subject, this research is limited to the logistical requirements necessary for combining aircraft engines shops to meet the composite fighter wing concept; i.e. A-10 (TF34-GE-100) engines and F-16 (F100-PW-200, F100-PW-220, and F110-GE-100) engines into one shop, and combining F-16 engines and F-15 (F100-PW-100 and F100-PW-220) engines into another shop. Emphasis will be placed on three specific areas: engine repair facilities, engine test facilities, and manpower.

Definitions

1. Tactical Air Forces (TAF): Part of the USAF consisting of the Tactical Air Command (TAC), United States Air Forces Europe (USAFE), Pacific Air Force (PACAF), Alaskan Air Command (AAC), The Air Force Reserve, and the Air National Guard.

2. Air Force Speciality Code (AFSC) 426X2: AF designation assigned to AF enlisted engine repair specialists, where X is determined by the skill, experience level, and rank of the specialist. Three basic levels of 3, 5, and 7 are used with a higher number referring to a higher skill and rank.

3. Engine Test Facility: A separate engine shop workplace where engines not installed in aircraft can be operated to determine the condition of the engine. Includes engine test cells and hush houses.

4. Close Air Support: Mission where the objective is to support surface operations by attacking hostile targets in close proximity to friendly surface forces.

5. Interdiction: Mission where the objectives are to delay, disrupt, divert, or destroy an enemy's military potential before it can be brought to bear effectively against friendly forces.

6. Counter Air: Mission where objectives are to gain control of the aerospace environment.

7. Base Repair Cycle: The time from engine removal to the time the engine is made serviceable at the jet engine intermediate maintenance (JEIM) shop. This cycle has two segments: The first is remove to start work, and second in work (at JEIM). Also called engine flow days or engine work days.

8. Pratt and Whitney (PW): Jet engine manufacturer producing the F100-PW-100 engine used in the F-15, the F100-PW-200 engine used in the F-16, and the F100-PW-220 engine used in the F-15 and F-16.

9. General Electric (GE): Jet engine manufacturer producing the TF34-GE-100 engine used in the A-10 and the F110-GE-100 engine used in the F-16.

10. Bench Stock Items: Frequently used, low cost parts or accessories, necessary in the daily repair of engines. The old parts are thrown away as cost to repair exceeds the cost to buy a new one.

11. Support Equipment: Tools (excluding normal hand tools), fixtures, or other items needed to repair an aircraft engine.

12. Squadron: Refers to 24 similar aircraft assigned to a unit.

Background

Since the Air Force was established in the US as a separate military service of the Department of Defense by the National Security Act of 1947, the Air Force has gone through many reorganizations (21:23-80; 23:360). After the Vietnam conflict, Air Force fighter wings were assigned a primary mission, such as air-to-air or air-to-ground, instead of being assigned multiple missions as previously done. This structure reflected the fact that newer fighter aircraft were more complex and capable than the aircraft pilots were exposed to in the past. The structure which assigned the wing a primary mission area allowed it to concentrate training efforts to improve tactical skills and efficiency of that one assigned mission (19:7-8). This is still the current structure of most Air Force wings in the USAF today.

Aircraft maintenance, a suborganization of AF aircraft wings, has also undergone many reorganizations. After the Vietnam War, aircraft maintenance shifted toward consolidation of aircraft repair specialists, an idea used earlier by General Curtis LeMay on bomber aircraft. Under the concept of consolidation or centralized maintenance, a centralized job control directed all aircraft maintenance activities in the wing. This centralized structure was adopted due to fiscal and manpower constraints. Centralized maintenance proved to be a very efficient peacetime structure (20:182; 7:64).

The centralized maintenance concept worked well for those wings which operated mainly from a home base, such as the Strategic Air Command (SAC), and the Military Airlift Command (MAC). However, it did not allow for a unit to be readily deployable or self-sufficient, and the Tactical Air Command (TAC) opposed the concept (21:65). In 1979, TAC abolished the centralized maintenance concept, and converted to a decentralized maintenance concept called the Combat Oriented Maintenance Organization (COMO). Under this decentralized structure, the job control center was replaced by a maintenance operations center which does not direct maintenance but merely monitors maintenance activities. Under COMO repair specialists were not consolidated. Instead they were moved out of the repair shops and onto the flightline to the greatest extent possible. The aircraft and repair personnel were then broken down into aircraft maintenance units (AMUs), and aligned with a Tactical Fighter Squadron (where the operational personnel are assigned). Moving repair personnel and aircraft to designated units on the flightline resulted in aircraft being fixed quicker than under the centralized

concept. More importantly, it allowed these small units of aircraft, maintenance units, and operations personnel to rapidly deploy and be relatively self-sufficient. Following TAC's conversion to the decentralized maintenance organization, the other components of the TAF began to follow suit (2:55-56; 7:64-65; 26:42-43).

Under both the centralized and decentralized maintenance structures, the engine repair shop remains basically the same. With centralized maintenance, all engine repair personnel are consolidated in the propulsion branch. Decentralized maintenance takes some of the engine repair specialist from the shop and moves them into AMUs on the flightline. Engine repair on the flightline is generally limited to troubleshooting, removing and reinstalling the engine, replacing externally mounted engine components, and some engine inspections. All major engine repair is still performed in the engine shop.

Engine repair shops at wing level in the AF are designed and manned based on the engine being maintained. Only one model, or type of aircraft engine is repaired in an engine shop. Bases, such as many SAC bases, which have two wings and two different types of aircraft assigned have two engine shops. Even at those TAF bases that have two types of aircraft with two different engines, such as the 363 Tactical Fighter Wing (TFW) which is assigned F-16s (F100-PW-200 engines) and RF-4Cs (J79-GE-15 engines), one engine repair facility is divided into two separate shops. Engine repair crews that work on the PW engines do not work on the GE engines. This form of engine repair separation is partly due to the way the Air Training Command (ATC) operates the engine repair technical school. The method being employed is a single course divided

into two parts. The first part provides general level/knowledge training and information about engines. The second part, is actual hands-on training where students train on an engine like the type they will see on their first assignment. Students are placed into the second part after they have received their orders. Thus, engine repair specialists are only qualified on one engine when they leave the school. Each additional assignment may be to a different engine. However, they are allowed to be qualified only on the current engine they are assigned to repair (9).

As new aircraft/engines are added to the Air Force inventory, the engines come with different or unique facility needs and support equipment requirements. Larger engines obviously need more work area than smaller engines. The engine or airframe manufacturer will usually provide the Air Force with a drawing and detailed list of the specific requirements of the engine shop which it feels is necessary to support maintenance on the engine. The shop layout proposed by the contractor normally does not match the configuration of existing Air Force engine shops. Building a new engine shop to meet the requirements of the new engine is expensive and time consuming and is seldom considered practical. Therefore, the Air Force normally modifies the existing engine shop to meet the size and facility requirements at the lowest cost. In the last 20 years, only one engine shop facility (the 313 Fighter Intercept Squadron at McChord AFB, WA) has been built within TAC for the engine still assigned to that base (9). Since engine shops in the Air Force have evolved to their present configuration through years of modifications, no two engine shops within the TAF are exactly alike.

Just as engine shops change over the years, so have the engines themselves. As technological advances occurred, engines changed to take advantage of the new technology. In recent history the technology has evolved from piston engines, to jet engines, to the most recent high performance augmented turbofan jet engines. New exotic materials, ceramics, and bold designs, aided by extensive research and development, have produced a new class of high thrust/low weight fighter aircraft engines. As the engines themselves became more sophisticated, so did the equipment used to repair them and maintain them. This equipment is commonly referred to as engine support equipment, and it ranges from trailers used to transport the engine from one spot to another, to hydraulic driven wrenches to remove/install load bearing support nuts. Some engine support equipment is the same for most engines, such as the stands used to support the engines. Other equipment is easily adapted for use on different engines. Yet, a major portion of today's support equipment is designed specifically for one engine, for one purpose. This has led to a proliferation of engine support equipment within the TAF (5; 9; 13; 23).

Investigative Questions

To decide upon the requirements for each type of composite fighter wing engine shop, several aspects of an engine shop must be examined. To insure each area is addressed, four investigative questions were designed. Each of the four questions involves a different component of an engine shop. The following questions will be used to guide this research effort.

1. What is the correct facility size for the composite fighter engine repair shop facilities?
2. Do any engine unique facility or configuration demands (ie special electrical power or overhead hoists) exist which must be included as part of the composite fighter wing engine shops?
3. What engine test facilities will be needed in each composite fighter wing, and are they interchangeable between the engines?
4. How many engine repair personnel, Air Force Speciality Code (AFSC) 426X2, are warranted by each composite fighter engine shop?

II. Literature Review

USAF History of Composite Fighter Units

Although called "a new force structure and employment concept" (27:11), the idea of a composite force structure within the USAF is not exactly new.

The idea of the Composite Air Strike Force is not a new one. General Kenney created the first unit of this type in March 1943. The idea was rekindled by the Tactical Air Command eleven years later (6:1).

In 1958 Lt Olin wrote an Airpower Report (17) on the Composite Air Strike Force (CASF) and its use in the cold war. This report was written after the Soviet Union had developed its own atomic weapons and the ability to deliver them to US soil. Major emphasis was placed on the Strategic Air Command (SAC) during this time period as the global force necessary to stop the Soviet Union. As Lt Olin pointed out, the use of this force in a war of limited scope would compromise our deterrent force for a total war. After atomic equality between the US and the Soviet Union occurred, massive retaliation was no longer a viable solution to meet levels of conflict less than total war. (See Appendix A for additional information on massive retaliation.) In response to this situation, a new concept was needed, and "the composite fighter force was born" (17:3). Lt Olin described the Composite Air Strike Force (CASF) as a tailored aerial task force to do a specific job under specific conditions, with a mission of deterring local or limited war or if such a war did break out, to be able to successfully cope with it. The force is comprised of units drawn from the entire TAC and then

placed under a single command. Lt Olin describes the CASF as able "to deliver a punch ranging from a light jab to a resounding haymaker" (17:6). The Force can be arranged into different sizes, making it applicable to a wide variety of offensive cold war plans.

Lt Col Bruce Carr, in his Air War College thesis (6), portrayed the creation of the CASF in much the same manner as Lt Olin. Lt Col Carr pointed out that in 1949 the U.S. was not the first to understand the impact of atomic equality. It was the Soviets who took the first step.

The Soviet Union's policy of open aggression was now one of peripheral nibbling. This was accomplished not with open use of Soviet forces, but by internal subversion within a noncommunist country. Our policy and forces for fighting this new type of war had to be changed to fit the situation. This was realized in 1954 when the United States had to sit back and watch the French be physically ejected from Indo China. The United States had no way to combat the situation (6:4).

To fill this void in US strategy, the United States planners developed the CASF, that was made up of fighters, light bombers, reconnaissance aircraft, tankers, and airlift aircraft. These units had the ability to rapidly deploy within a matter of hours to anywhere in the world. The CASF is based upon this concept of rapid movement or deployment, and freedom of action. Lt Col Carr explains that with atomic and thermonuclear parity between the Communist world and the free world, Russia in continuing its path of world domination began using such methods as "internally instigated coups, subversion, and other economic, political, and military means" (6:12), which could lead directly or indirectly to a limited war. Therefore, IAC, and the CASF in particular, was especially tailored to fit this form of contingency. This lead the CASF to become known as the small war deterrent, and SAC the major war deterrent. With the invention of the CASF, came the

logical need of a method to control the force. Nineteenth Air Force was created in 1954 to provide this command and control element. The Nineteenth Air Force controlled units tailored in size to meet situations ranging from a Communist instigated internal unrest in a small country, to a full scale local war such as Korea (6:1-35).

Although the Nineteenth Air Force, as such, is no longer in existence, the idea of a highly mobile composite fighter force remains alive within the Tactical Air Force (TAF). When Maj Ronald Rushing wrote about the training being conducted to prepare the TAF for war, he found an increase in the use of training that involved composite forces (19:8-36). During Maj Rushing's historical research, he found that after the cease-fire in Korea, strategic doctrine and nuclear weapons once again were the dominant element of U.S. national defense. SAC was the cornerstone of the defense policy. The overwhelming air-to-air successes by TAF units in Korea provided a false sense of security to the TAF as it was believed little training was needed to maintain proficiency.

Aircrews flew a variety of missions and became "jacks of all trades" and in reality, masters of none. Diversification gave aircrews mission exposure, but it did not allow for in depth concentration of individual tactical skills (19:4).

When the U.S. entered the Vietnam conflict, the results of air-to-air encounters were dismal compared to Korea. Again, the USAF rekindled the composite force concept and used it extensively during the Vietnam conflict on missions such as "Linebacker" (19:5-6,27). (Appendix B contains a summary of the Linebacker campaign.) After Vietnam, as USAF aircraft became more complicated, operational views began to change.

TAC Fighter Wings were given a primary mission (air-to-air or air-to-ground) and required to concentrate their training efforts toward that mission, and to dedicate more attention to the improvement of specific tactical skills (19:8).

It might appear that this shift toward single mission wings meant the end of composite force structuring. But, Maj Rushing did not find this to be the case. The final mission of a typical scenario at Red Flag is the composite strike. (The Red Flag training program is explained in Appendix C.) In fact, this is the most complicated scenario as it involves all the participating units, including Combat Air Patrol (CAP) as escort, Electronic Counter Measure (ECM) aircraft for jamming, Wild Weasel aircraft for suppressing Surface to Air Missiles (SAM's), and reconnaissance aircraft for bomb damage assessment photography. Also included are SAC bombers and TAC F-111s (19:18-19). The inclusion of a composite force strike as part of one of the Air Force's most important training programs portrays how important the composite force structure still is. Unfortunately, the number of participants in Red Flag training is very limited. Therefore, TAC developed Composite Force Training (CFT) to bridge the gap between Red Flag training and the normal daily flying accomplished at a units permanent location. CFT allows for a force made up of different aircraft with dissimilar roles to accomplish a specific mission, providing a realistic training environment. The use of composite force training is growing in all areas of the TAF, and is much in line with the practice/train as you intend to fight theory (19:28-36).

New Concept of Composite Fighter Wings

As Colonel Robert Wiswell developed his concept of composite fighter wings as the new force structure in both his Air War College Thesis (28) and AF Journal of Logistics article (27), the idea grew from an existing structure. However, the manner and level in which he foresees implementing the composite force is new and innovative. The CASF previously talked about involved taking (or using) squadrons or units from different wings, putting them under one (new) command and control, responding to the tasking, then returning the forces to their own units. Col Wiswell's concept of a composite fighter force calls for force elements to be assigned to a common wing level organization. Col Wiswell believes:

A new structure is warranted that allows commitment of a self contained force drawn from preconfigured fighter wings specifically built to deploy, employ, and withdraw without having to pull bits and pieces from the homogeneous wings that now exist (27:11).

In other words, Col Wiswell believes the TAF needs permanent composite forces at the wing level. These wings would make use of A-10s, F-16s, F-15s, and the new AFF, to perform counter air, interdiction, and close air support roles. The type and mix of aircraft would be determined by which of the three missions a particular wing was assigned. Unlike previous composite forces, these fighter wings allow for the ability to "launch from one base all facets of the strike force package" (27:11), under the same command and control as they are normally under, respond to the tasking, and then return to the same home base. Of course, the composite wing structure is not as complex as the

composite force; tankers, bombers, and airlift aircraft are not included. In fact, Col Wiswell does not include RF-4C, F-4G Wild Weasel, F-111, or EF-111 aircraft. Col Wiswell foresees the introduction of very high speed integrated circuit technology (VHSIC), to convert A-10s, F-16s, and F-15s to perform RF-4C and F-4G missions. As this occurs, these aircraft will be removed from the active inventory. Since the F-111 and EF-111 perform such unique missions, they would be left as they presently are. The aircraft that replace the F-111s and EF-111s would then be compatible with the composite wing structure (28:20-21). Col Wiswell envisions the composite fighter wings to be composed of:

Three basic wing configurations. The composite close air support wing would have two A-10 squadrons and one F-16 squadron, or three A-10 squadrons. In the A-10/F-16 composite wing the F-16s would be for counterair escort and combat air patrol, defense suppression, and limited tactical reconnaissance. The two A-10 squadrons would perform the basic close air support mission... The close air support wing of three A-10 squadrons would perform basic close air support and be more extensively tasked for airborne FAC... The interdiction composite wing would have two F-16 squadrons and one F-15 squadron (the F-15E dual role fighter could be used as the F-15 squadron). This would provide integral wing capability for interdiction, pre- and post-strike reconnaissance, defense suppression, and counterair escort and combat patrol. The counterair composite wing would have two F-15 squadrons and one F-16 squadron or two F-16 squadrons and one F-15 squadron. These wings ... would perform classic counterair missions of area combat air patrol, local air defense, and escort of high value assets like the AWACS ... (27:12).

Based on the above quote, Table 1 shows the different aircraft combinations possible for each of the three types of composite fighter wings proposed by Col Wiswell.

Table 1
Composite Wing Structures

		Aircraft Types (by Number of Squadrons)		
		A-10	F-15	F-16
Composite Wing Type	Close Air Support	3		
		2		1
	Interdiction		1	2
	Counter Air		2	1
			1	2

Composite Fighter Wing Aircraft Engines

In February 1984, the Air Force announced a decision on the Alternate Fighter Engine (AFE) competition and purchased both the F110-GE-100 engine for the F-16 and the F100-PW-220 engine for the F-15. In January 1985, the Air Force announced the 1986 engine buy split between the GE and PW engines which placed the F100-PW-220 engine in the F-16 also (3:51-52). Table 2 portrays the possible aircraft and engine combinations available to be placed into composite fighter wings.

Table 2
Aircraft/Engine Combinations

	Aircraft Type		
	A-10	F-15	F-16
TF34-GE-100	X		
F100-PW-100		X	
Engine Type F100-PW-200			X
F100-PW-220		X	X
F110-GE-100			X

From Tables 1 and 2 it can be determined that 16 different composite engine shops could conceivably exist, based on the number of squadrons of aircraft and on the type of engine installed in the aircraft. Appendix D shows the different combinations of composite fighter wing types by aircraft/engine combinations. Listed in Table 3 are the 16 different engine shops that could be possible under the proposed composite fighter wing structure:

Table 3
Composite Fighter Wing
Engine Shop Combinations

Type of Aircraft	Number of Squadrons	Type of Engine
1) A-10	3	TF34-GE-100
2) A-10	2	TF34-GE-100
F-16	1	F100-PW-200

Table 3 (continued)

Type of Aircraft	Number of Squadrons	Type of Engine
3) A-10	2	TF34-GE-100
F-16	1	F100-PW-220
4) A-10	2	TF34-GE-100
F-16	1	F110-GE-100
5) F-16	2	F100-PW-200
F-15	1	F100-PW-100
6) F-16	2	F100-PW-220
F-15	1	F100-PW-100
7) F-16	2	F110-GE-100
F-15	1	F100-PW-100
8) F-16	2	F100-PW-200
F-15	1	F100-PW-220
9) F-16	2	F100-PW-220
F-15	1	F100-PW-220
10) F-16	2	F110-GE-100
F-15	1	F100-PW-220
11) F-15	2	F100-PW-100
F-16	1	F100-PW-200
12) F-15	2	F100-PW-100
F-16	1	F100-PW-220
13) F-15	2	F100-PW-100
F-16	1	F110-GE-100
14) F-15	2	F100-PW-220
F-16	1	F100-PW-200
15) F-15	2	F100-PW-220
F-16	1	F100-PW-220
16) F-15	2	F100-PW-220
F-16	1	F110-GE-100

The list of composite fighter engine shops in Table 3 can be broken down into the three types of composite wing structures proposed by Col

Wiswell. Under Close Air Support Wings would be combinations 1 - 4 . Interdiction Wings consist of combinations 5 - 10. Counter Air includes combinations 5 - 16 as 5 - 10 would be possible combinations for either Interdiction or Counter Air Wings.

Composite Fighter Wing Concept Commentaries

The researcher found only one article which addressed the composite fighter wing concept as proposed by Col Wiswell.

Maj Eugene Leach, a member of the Air Command and Staff College Faculty, offered his solutions or ideas (16) to the three major areas of concern (as proposed by Col Wiswell): facilities, spares, and manpower.

Maj Leach believes there are no show stoppers in the area of facilities (16:6). He reaches this conclusion by using an example: moving an F-16 squadron from Shaw AFB to Myrtle Beach AFB and deleting (or transferring) one A-10 squadron from Myrtle Beach. He further compares this move to a Red Flag exercise. Major Leach believes that current facilities for performing off equipment work already exist. Facilities for the F-16 avionics are available because the A-7s assigned to Myrtle Beach before the A-10s required more avionics maintenance space than the A-10 requires. If the required avionics test equipment could not be moved to Myrtle Beach, a backup plan was presented by Major Leach. This plan consisted of daily shuttles from Shaw to Myrtle Beach plus additional cannibalization, to meet daily sortie requirements.

In the area of aircraft engines, Major Leach reports that TF34-GE-100 (A-10) engines and F100-PW-200 (F-16) engines have different repair concepts, based on what work he believes is performed on each

engine at base level. Major Leach feels "a commercially available prefabricated metal building set on a concrete slab could provide the additional engine module storage space" (16:6) to resolve any space problems that may exist when present engine shops are converted to composite engine shops and must repair more than one engine.

Maj Leach portrays spares as having a minimal, if any, impact on converting to a composite fighter wing. This is based on the idea that we can simply transfer the entire War Readiness Supply Kit (WRSK) assigned to the squadron that is transferring. Major Leach points out, that "adjustments in spares/WRSK stockage levels should be made" (16:6).

Because more people would probably be required, Maj Leach thinks manpower is the largest obstacle the composite fighter wing faces (16:6). Two suggestions are offered to resolve this problem. The first is the use of additional cross utilization training allowing repair personnel to work on more than the system they were trained on. The second is to allow repair personnel to be qualified on two aircraft/aircraft systems at the same time - something which is currently not allowed.

Maj Leach ends his discussion with the following comment:

All these factors boil down to this: the using command logistics infrastructure could make the composite wing work right now if told to do so. This has been the case in the past (16:6).

The above comment recognizes the historical cases where hard work and creative leadership have combined to overcome organizational or bureaucratic obstacles. The composite fighter wing is too valuable and important as a concept to implement without thorough studies of its logistics related implications. Maj Leach's overview does not treat the

subject in sufficient depth to help make informed decisions. This research effort provides a partial in-depth review of some of the issues associated with the composite fighter wing engine shops.

III. Methodology

Introduction

The objective of this research was to determine some of the applicable requirements necessary for each type of engine shop that will be found within the composite fighter wing structure. To answer the research questions required data collection and analysis of that data. Data was collected from AF manuals and regulations, engine manufacturer technical representatives, Air Force technical data publications, manpower listings, and Headquarters (HQ) TAC Engine Program Managers.

Guidelines And Procedures

To assist in achieving the research objective, the following plan was used:

1. Using the engine shop size formulas from Air Force Manual (AFM) 86-2 (11) and necessary data which the formula required (i.e, engine flow days) from Technical Order (TO) 2-1-13 (10), and the engine manufacturers, the square footage authorizations were computed. The square footage for one, two, and three squadrons of each type aircraft/engine used in the composite fighter wing structure were figured, using a hand calculator. The researcher took this data and adjusted it as required against the squadron make up of each possible composite fighter engine shop, and the individual square footage figures were added up. The result was the square footage for every particular composite wing engine shop type (question 1).

2. The researcher gathered data from HQ PAC and the engine manufacturers on special facility needs such as compressed air, water, and electricity. These distinctive needs were then listed for the appropriate engines. A table was designed to show some of the facility requirements for any composite fighter wing engine shop (question 2).

3. Based on contractor and AF technical data for each specific engine, the types of engine test facilities were identified. The researcher examined the test facility requirements to determine similar and unique requirements and listed the basic test facility requirements for each composite fighter wing.

4. Based on current manpower requirements for engine repair personnel on each model engine, the manpower requirements for composite fighter wing engine shops were calculated. By using current manpower requirements for each type of engine, the researcher added the requirements, with a hand calculator, for the engine types in each composite engine shop to arrive at the total manpower requirements for engine repair personnel at each different shop (question 4).

Application of Data

After answering the investigative questions posed in chapter 1, the researcher sorted the data and produced separate tables for each area researched, for each type of composite fighter wing engine shop. The tables stated the type and number of squadrons of each engine involved, as appropriate. The tables/data were arranged to show for each engine shop:

1. The correct facility size in square footage.
2. Unique facility and configuration needs.
3. Test facility requirements.
4. Overall manpower requirements.

One final table was produced to show the range of requirements for facility sizes, test facilities, and manpower for each of the three basic composite fighter wing structures. If any engine shop in the TAF were considered for conversion into a composite fighter wing engine shop, that engine shop could be compared against the requirements listed in the applicable tables. This comparison would show if the engine shop under review is large enough to be converted to that composite shop. The comparison would reveal any additional test facilities that would be required, and if any unique facility or configuration changes are necessary. Finally, manpower requirements for the composite engine shop can be used to specify the increase or decrease in the current manpower level of the engine shop under review.

IV. Findings

Facilities

Facility Size Requirements. Engine manufacturers develop specifications for the "ideal" engine shop to be associated with each new engine entering the Air Force inventory. However, the Air Force does not normally build engine shops according to those specifications. Instead it has developed another method for integrating new engines into the active inventory. The procedure uses existing facilities and converts them to meet the needs of the new engine.

To determine the correct facility size for an engine shop, the Air Force makes use of the following formula which is documented in AFM 86-2 (11).

$$\text{Shop Space Authorized} = A \times B \times C \times D / E \quad (1)$$

Where

A = Support Space from Table 8-3, AFM 86-2

B = Base Repair Cycle time from Table 4-1, F.O. 2-1-18 (10:4-2)

C = 1/2 number of installed engines for the authorized aircraft

D = Engine work space, 2 X engine length X 4 X engine width, or
use Table 8-3, AFM 86-2 (11:vi.A.7)

E = Average number of work days per month, which is 22

In addition to the basic formula, an adjustment factor is used with F100 PW engines maintained by units that are not organized as a standard 72 Possessed Assigned Aircraft (PAA) wing. The formula is adjusted for

those wings with less than 72 possessed aircraft by multiplying the formula by 1.3 (equation 2). For those wings with more than 72 possessed aircraft, the formula is multiplied by .85 (equation 3).

For F100 wings less than 72 aircraft

$$\text{Shop Space} = 1.3 \times (A \times B \times C \times D / E) \quad (2)$$

For F100 wings greater than 72 aircraft

$$\text{Shop Space} = .85 \times (A \times B \times C \times D / E) \quad (3)$$

The use of these adjustment factors provides smaller units the necessary additional space to store large bulky special tools, mobility equipment/tooling, and allow for a repair/inspection area for nonpowered support equipment. Larger units are trimmed of excess space created by the basic formula which is not required. Even though more engines are being supported, a smaller amount of additional space is required (7; 23).

Using the above formulas and the aircraft/engine information provided in Table 2 (page 17) facility requirements for each type of a 24 aircraft squadron was computed and is shown in Table 4. Actual computations are in Appendix E. All numbers are in square feet, and have been rounded off to the nearest whole square foot.

Table 4

Facility Size Requirements
For Single Aircraft Squadrons

Aircraft	Engine	Facility Size
A-10	TF34-GE-100	10,282
F-15	F100-PW-100	20,068
	F100-PW-220	11,630
F-16	F100-PW-200	14,832
	F100-PW-220	8,343
	F110-GE-100	8,343

Composite wing facility requirements are computed by taking the above data and applying it to the composite fighter wing structures shown in Table 3. This is modified by use of the adjustment factors previously discussed. Table 5 presents the total facility requirements, in square feet, for each possible engine shop. Detailed computation information is in Appendix F.

Table 5

Composite Fighter Wing Engine Shop
Facility Size Requirements

Aircraft Type	Number of Squadrons	Engine Type	Facility Size
Close Air Support			
A-10	3	TF34-GE-100	30,845
A-10	2	TF34-GE-100	
F-16	1	F100-PW-200	39,345

Table 5 (continued)

Aircraft Type	Number of Squadrons	Engine Type	Facility Size
A-10	2	TF34-GE-100	
F-16	1	F100-PW-220	31,409
A-10	2	TF34-GE-100	
F-16	1	F110-GE-100	28,906
Interdiction			
F-16	2	F100-PW-200	
F-15	1	F100-PW-100	65,441
F-16	2	F100-PW-220	
F-15	1	F100-PW-100	48,570
F-16	2	F110-GE-100	
F-15	1	F100-PW-100	43,563
F-16	2	F100-PW-200	
F-15	1	F100-PW-220	53,682
F-16	2	F100-PW-220	
F-15	1	F100-PW-220	36,810
F-16	2	F110-GE-100	
F-15	1	F100-PW-220	31,805
Counter Air			
F-15	2	F100-PW-100	
F-16	1	F100-PW-200	73,036
F-15	2	F100-PW-100	
F-16	1	F100-PW-220	64,600
F-15	2	F100-PW-100	
F-16	1	F110-GE-100	63,215
F-15	2	F100-PW-220	
F-16	1	F100-PW-200	49,519
F-15	2	F100-PW-220	
F-16	1	F100-PW-220	41,083
F-15	2	F100-PW-220	
F-16	1	F110-GE-100	38,580

Note: All Interdiction shops are also possible under Counter Air

Unique Facility Requirements. After comparing the five different engines involved in the composite wing structure, the researcher found that only the F100 engines have a special construction/utility requirement. This was a power requirement (23; 5). The F100 engine requires:

1. 480 volt AC, 60 Hz electricity (using #30/3 wire).
2. 115 volt AC, 400 Hz electricity (using #10/2 wire).

Although many engine shop requirements such as fire protection systems, ventilation, and lighting exist, some of the requirements for all five engines seemed worthy of note (7; 23; 5). These are listed in Table 6.

Table 6
Composite Fighter Wing Engine Shop.
Facility Considerations

<u>Area</u>	<u>Requirement</u>
Floors	A uniform floor loading of 155 pounds per square foot to support engine maintenance.
Crane/Hoist	A bridge crane system to accommodate hoisting of the engine/engine parts. A minimum overhead clearance of 14 feet is required.
Compressed Air	A compressed air system capable of providing a flow rate of 150 scfm at 125 psi.
Electrical Power	120 volt AC, 60 Hz (# 10/2 wire). 120/240 volt AC, 60 Hz (# 10/3 wire). 240/120 volt AC, 60 Hz (# 30/4 wire).

Table 6 (continued)

<u>Area</u>	<u>Requirement</u>
Cold Water	Four cold water outlets providing 30-50 psi at a flow rate of 28-37 gpm. Two cold water outlets in the wash room, one providing 30-50 psi at a minimum flow rate of 2 gpm, the other providing 25-125 psi at a maximum flow rate of 5 gpm.

Note: The crane/hoist system is not a true requirement for the TF34-GE-100 or F110-GE-100 engines. However, it would replace the portable cranes currently being used and provide repair personnel a more efficient means of engine repair (13; 23).

Engine Test Facility Requirements

After an engine is worked on or repaired (sometimes even before it is worked on) the engine must be started and run at different speeds. To provide the ability to run engines for test, the Air Force uses engine test cells. The test cell consists of a cab for the operator to use, and a test bed for mounting the engine. The test cell is installed on a concrete pad with the engine exposed (called an open pad) or installed in a building (called a noise suppressor system (NSS)) that uses either water or air for cooling the engine exhaust. Some test cells can also be installed in hush houses which are large building designed to enclose the whole aircraft or just an engine. Hush houses (AM37T-10) use air for cooling (1; 5; 24).

There are three test cells used for the TF34, F100 and F110 engines. These are:

1. AM37T20 (called the T20)
2. AM37T6 (called the T6)
3. AM37T6C (called the T6C)

All three of the test cells can be installed in the following water cooled NSS's currently used by the AF:

1. AM37T-2
2. AM37T-3
3. AM37T-7
4. AM37T-8

The T20 can also be used in:

1. AM37T-10 Hush house
2. AM37T-9 Air cooled NSS

By using adaptor kits, all five of the engines maintained by the composite fighter wings can use any of the three test cells. Table 7 shows the adaptor kit required for each engine before it can be mounted on one of the test cells.

Table 7
Test Cell Adaptor Kits

Engine	Adaptor Kit Required
TF34-GE-100	Part Number 50-1000
F100-PW-100	Part Number PWA 50079
F100-PW-200	Part Number PWA 50080
F100-PW-220	Part Number PWA 50047
F110-GE-100	Stock Number 3C3801

Since any of the five engines can fit on any of the current test cells through the use of an adaptor, no specific test cell requirement exists for composite fighter wing engine shops. It should be pointed out that when an adaptor kit is installed on a test cell the instruments used on the test cell must be calibrated. This is a lengthy procedure

and can only be accomplished by Precision Measurement Equipment Laboratory personnel. This calibration normally takes two 8 hour shifts if no problems are found. Problems must be corrected before the calibration can be finished (1). For this reason, it is important for a composite fighter wing with multiple types of engines to have a separate test cell to support each engine. Currently, TAC assigns two hush houses and one test cell to every 72 PAA wing. Additional test cells are then assigned to wings with mobility commitment based on the number of independant and dependant squadrons they maintain (13; 24). Table 8 shows what is believed to be the correct number of engine test facilities each composite fighter wing will require (1; 5; 9).

Table 8
Composite Fighter Wing
Test Facility Requirements

Composite Wing Type	Aircraft Type	Number of Squadrons	Engine Type	Test Facility Requirements
Close Air Support				
1)	A-10	3	FF34-GE-100	3
2)	A-10	2	FF34-GE-100	4
	F-16	1	F100-PW-200	
		or	F100-PW-220	
		or	F110-GE-100	
Interdiction				
1)	F-16	2	F100-PW-200	4
	F-15	1	F100-PW-100	
		or	F100-PW-220	
2)	F-16	2	F110-GE-100	
	F-15	1	F100-PW-100	4
		or	F100-PW-220	

Table 8 (continued)

Composite Wing Type	Aircraft Type	Number of Squadrons	Engine Type	Test Facility Requirements	
	3)	F-16	2	F100-PW-220	3
		F-15	1	F100-PW-220	
	4)	F-16	2	F100-PW-220	4
		F-15	1	F100-PW-100	
	Counter Air				
	1)	F-15	2	F100-PW-100	4
	F-16	1	F100-PW-200		
		or	F100-PW-220		
		or	F110-GE-100		
	2)	F-15	2	F100-PW-220	4
		F-16	1	F100-PW-200	
			or	F110-GE-100	
	3)	F-15	2	F100-PW-220	3
		F-16	1	F100-PW-220	

Manpower Requirements

Just as different engines require different size work spaces and facilities, they also require different numbers of repair personnel to maintain them. Table 9 shows the number of engine shop repair personnel required for each type of composite fighter wing engine (7; 24). Requirements are shown for one, two, and three squadrons of each possible aircraft/engine combination.

Table 9
Personnel Requirements by Engine Type

Aircraft/Engine	One Squadron	Two Squadrons	Three Squadrons
A-10			
TF34-GE-100	34	62	85
F-15			
F100-PW-100	44	69	113
F100-PW-220	35	51	86
F-16			
F100-PW-200	37	50	87
F100-PW-220	34	41	75
F110-GE-100	34	43	77

Additional manpower data in greater detail is provided in Appendix G.

The engine repair personnel requirements for each type of composite fighter wing engine shop are determined by taking the information from Table 9 and placing it against each type of aircraft/engine shop as detailed in Table 3. The results of this are shown in Table 10. Appendix H shows the total requirements for each individual type of aircraft/engine and number of squadrons. It also indicates how the total manpower requirements are added to achieve the total shop requirement.

Table 10

Composite Fighter Wing Engine Shop
Manpower Requirements

Composite Wing Type	Aircraft Type	Number of Squadrons	Engine Type	Total Manpower Requirement
Close Air Support				
1)	A-10	3	TF34-GE-100	85
2)	A-10	2	TF34-GE-100	99
	F-16	1	F100-PW-200	
3)	A-10	2	TF34-GE-100	96
	F-16	1	F100-PW-220	
		or	F110-GE-100	
Interdiction				
1)	F-16	2	F100-PW-200	94
	F-15	1	F100-PW-100	
2)	F-16	2	F100-PW-220	35
	F-15	1	F100-PW-100	
3)	F-16	2	F110-GE-100	37
	F-15	1	F100-PW-100	
4)	F-16	2	F100-PW-200	85
	F-15	1	F100-PW-220	
5)	F-16	2	F100-PW-220	76
	F-15	1	F100-PW-220	
6)	F-16	2	F110-GE-100	73
	F-15	1	F100-PW-220	
Counter Air				
1)	F-15	2	F100-PW-100	106
	F-16	1	F100-PW-200	
2)	F-15	2	F100-PW-100	103
	F-16	1	F100-PW-220	
		or	F110-GE-100	

Table 10 (continued)

Composite Wing Type	Aircraft Type	Number of Squadrons	Engine Type	Total Manpower Requirement
3)	F-15	2	F100-PW-220	88
	F-16	1	F100-PW-200	
4)	F-15	2	F100-PW-220	85
	F-16	1	F100-PW-220	
		or	F110-GE-100	

Summary

Due to the extensive amount of data presented in this chapter, Table 11 attempts to draw the data together by providing a short summary of some of that data. Table 11 shows the range of facility sizes, the number of test facilities, and the range of manpower requirements for each of the three basic composite fighter wing structures. This table does not include special facility requirements, nor does it list every possible type engine shop. It is designed to be a quick reference guide.

Table 11

Summary Table For Composite Fighter Wing Engine Shop Requirements

Composite Fighter Wing Structure	Square Footage Requirements	Test Facility Requirements	Manpower Requirements
Close Air Support	28,906 - 39,845	3 - 4	85 - 99
Interdiction	31,805 - 65,441	3 - 4	76 - 94
Counter Air	38,580 - 73,036	3 - 4	85 - 106

V. Conclusion And Recommendations

Conclusion

In trying to evaluate Col Robert A. Wiswell's proposal, this study has focused on showing composite fighter engine shops needs in the areas of facility sizes, test facilities, and manpower. In determining the facility size requirements, the researcher used the latest available data on base repair cycle time. The recent increase in the base repair cycle time from 9 days to 16 on the F100-PW-100/200 engines caused an enormous increase in the facility size for these engines. Under the 9 day cycle a 72 F-15 aircraft wing required an engine shop size of 34,889 square feet. With a 16 day cycle, this shop is authorized 62,025 square feet. The same effect is seen in an F-16 wing of 72 aircraft where the authorized shop size increases from 25,029 to 44,496 square feet. Therefore, the researcher cautions the reader to be careful if using the facility figures where F100-PW-100/200 are involved. The researcher suggests using the figures for the F100-PW-220 in their place until the full effect of the increase in the base repair cycle time is understood. All other figures used in this study can be used as intended. They are base line requirements from which to compare the build versus convert alternatives for current or future engine shops as part of a composite fighter wing.

Even using the old repair cycle times as suggested above, the researcher concludes that converting existing engine shops to composite engine shops will create some logistical impacts that would need to be

resolved. Please note that converting an existing A-10 wing to a composite Close Air Support Wing consisting of 3 A-10 squadrons would actually be only a name change and no logistical impacts would occur. Since this conversion need not be addressed, there are 15 possible composite fighter shops to examine. Even with only these 15 different types of composite engine shops it is conceivable that 30 different conversion plans are possible if current A-10, F-15, and F-16 wings are reformed into composite fighter wings. For example, a current 3 squadron F-16 wing with F100-PW-200 engines installed, can be transformed into five different composite engine shops. It could be converted into a Close Air Wing made up of two squadrons of TF34-GE-100 engines (A-10s), and one squadron of F100-PW-200 engines (F-16s). It could be reformed into two different Interdiction Wings, the first with two squadron of F100-PW-200 engines (F-16s) and one squadron of F100-PW-100 engines (F-15s), or a second type of two squadrons of F100-PW-200 engines (F-16s) and one squadron of F100-PW-220 engines (F-15s). Or, it could be remade into two different Counter Air Wings, one with one squadron of F100-PW-200 engines (F-16s) and two squadrons of F100-PW-100 engines (F-15s), or one with one squadron of F100-PW-200 engines (F-16s) and two squadrons of F100-PW-220 engines (F-15s).

In all but two cases, converting a current 72 PAA A-10, F-15, or F-16 wing engine shop to a composite engine shop will require an increased facility size. The increase may be as small as 564 square feet or as much as 16,054 square feet. The two exceptions would be converting an A-10 wing to a Close Air wing with two A-10 squadrons and one F-16 squadron (having F110-GE-100 engines). The other case is converting an F-15 wing to an Interdiction wing made up of two F-15

squadrons (F110-GE-100 engines) and one F-15 squadron (F100-PW-100 engines). An additional engine test facility will be required when the conversion places two different engines into the same composite wing. This occurs in every case except when combining F-15s and F-16s that both have F100-PW-220 engines. In over 75 percent of the conversions (23 out of 30), manpower increases would be necessary. These increases range from a personnel increase of one, to an increase of 14 personnel.

Although these logistical impacts would occur, they are not enormous, and careful planning prior to composite wing restructuring can insure the impacts are minimized. Except in the area of facility size increases, the logistical impacts can be effectively handled. Those conversions which require an additional engine test facility could either arrange their existing test facilities to support both engine types (while creating perhaps a small backlog of engines), or construct an open test cell pad (5; 9). The manpower shortages would be reduced by the change in mobility commitment brought about by restructuring to composite fighter wings. Under the present structure, operational wings may be assigned a 2-way or 3-way mobility commitment. Those wings assigned a 3-way commitment are authorized additional personnel. As an example, an F-15 wing with a 2-way commitment is authorized 113 engine shop personnel, while the same wing with a 3-way commitment is authorized 132 engine shop personnel. The composite fighter wing structure would eliminate 3-way commitments simply because wings would no longer have three identical squadrons they could send to three different locations. Thus, these additional authorizations could be used to help offset the increases required by the restructuring (9).

In those transformations that require larger facilities, only two alternatives are available if the facility cannot be enlarged due to money, time, or location constraints. The first alternative is to do nothing and force everything into the existing facility. The second is to construct a storage building for the additional equipment/tools and parts. Neither of these alternatives are true solutions even though they have been used in the past, but it is possible to use one of them as an interim measure (9; 13; 24).

Although permanent solutions to the logistical impacts that would arise in changing to a composite fighter wing structure are not immediately available, alternatives do exist that would allow for the conversion to be accomplished. The advantages which the composite structure offers over the current structure perhaps warrants the use of alternative temporary solutions in order to convert the present IAF engine shops into shops capable of supporting composite wings. The use of temporary measures would allow the IAF to begin switching to a composite structure and allow permanent solutions to be accomplished at some future time.

However, determining numbers or sizes does not answer one basic question: Are composite fighter wing engine shops possible from a management viewpoint? Although the answer to this would require additional study, the researcher felt a preliminary answer was necessary to properly conclude this report. The researcher contacted CMSgt James B. Hall (14). Chief Hall's propulsion shop was selected as the best in TAC in both 1985 and 1986. Chief Hall was asked what he thought of combining maintenance on different engines into one shop, such that

repair personnel and supervisory personnel were responsible for both types of engines. Chief Hall strongly believes that the quality of our airmen and NCO's is more than enough to overcome the problems of maintaining two different engines in one shop. This is not an in depth answer to the question posed, but the researcher believes that it does help show the composite fighter wing structure is a viable structure requiring further study.

Recommendations For Further Study

Several unanswered issues remain.

1. What general or engine specific tools/support equipment does each type of composite engine shop need?
2. Are any of the current bench stock items or spare engine parts interchangeable between different engines, and can they be combined to reduce the overall requirement for these items?
3. What is the effect on supply of having to support two different engines within the same wing?
4. How will AIC basic engine training and field training detachment (FTD) units be affected due to the need to prepare/train personnel on two different engines?

The above list is certainly not all inclusive. Aircraft engines are just one aspect of an aircraft that would be impacted by converting to a composite fighter wing structure. What the researcher has accomplished in this study and suggested above can easily be expanded to include other aircraft systems such as avionics, fuels, structural repair, etc.

The logistical impacts within these areas should also be examined to determine the logistical feasibility of converting the FAF to a composite wing structure. The researcher encourages these studies to be

undertaken as the idea of a composite structured IAF may be vital to this nation as the US seeks to protect its' own freedoms, and the freedom of others.

Appendix A: Massive Retaliation

In the mid 1940's, after the US developed the atomic bomb, and the means to deliver it, the US military strategy of deterrence emerged. The concept of deterrence was dependant upon the threat of massive retaliation. Massive retaliation was aimed at deterring Soviet Union military aggression against other countries. While the US was the only country with atomic weapons and the long range aircraft needed to deliver the weapons, the US was able to militarily threaten the Soviet Union with nuclear devastation of her homeland if she continued the goal of world domination by Communism through military means. Massive retaliation then, was actually an extension of the theory of peace through strength (6:1-3; 17:1; 23:360).

In 1949 and the early 1950's, as the Soviet Union developed their own atomic weapons, plus the means to deliver them, the US lost its previously clear monopoly in atomic weapons. As the quantity and quality of Soviet atomic power became comparable to the US, massive retaliation was no longer valid and was replaced by mutual deterrence. Under mutual deterrence both sides have the military ability to deliver a devastating offensive blow, yet are unable to survive an equally devastating counterblow by the other side (6:3-4,7-13; 17:1-2).

Appendix B: Linebacker

During the US involvement in the Vietnam conflict, two major US bombing campaigns were waged over North Vietnam. The first, during the Presidency of Lyndon Johnson, was called Rolling Thunder, and lasted from 1965 to 1968. The main emphasis was air attacks against lines of communication targets in the southern part of North Vietnam. The strikes proved useful in hindering the movement of material to the south, but did little to bend the will of Hanoi. The second campaign happened under the Presidency of Richard Nixon and was named Linebacker, although it is normally broken down into two phases, Linebacker I and Linebacker II. Linebacker occurred during 1972 (4:31-10 to 31-16).

The North Vietnam invasion of the northern part of South Vietnam on Good Friday, 30 March 1972 (18:34-28) prompted the US to begin daily fighter-bomber strikes against North Vietnam beginning on 6 April 1972 (4:31-14). Then on 8 May, President Richard Nixon announced his decision to mine the major ports of North Vietnam and increase the bombing offensive; thus Linebacker was born. Linebacker used a composite force made up of B-52s and tactical fighters and delivered such weapons as guided 2000 and 3000 pound conventional bombs. Linebacker had as its objectives to disrupt the supply lines supporting the North Vietnamese invasion, destroy the internal military stockpiles and slow down the external resupply of those stockpiles, destroy targets within North Vietnam which were supporting their war effort in South Vietnam, and restrict the overall flow of men and equipment to the

battlefield. The overall objective was to "sap the foundations of the enemy's desire to prolong the conflict by hampering its ability to conduct sustained operations" (18:34-29). Linebacker, just like Rolling Thunder, was not intended to destroy the Hanoi regime or devastate North Vietnam.

Unlike Rolling Thunder, the White House did not select the targets in the Linebacker campaign. This allowed greater flexibility in planning and better utilization of forces. In Rolling Thunder, repetitious strikes were made on those targets selected by the White House for that week. This enabled North Vietnam to concentrate their defenses to defend the target. In Linebacker I, units could attack targets in one area; and as the North Vietnamese moved their defenses accordingly, new, less defended targets could be attacked.

On 23 October 1972, the White House ordered the Air Force to cease air operations north of the 20 degree N line, ending Linebacker I. Linebacker II began on 18 December 1972; and although a continuation of Linebacker I, it differed in two areas. First, increasing pressure within the US for a resolution to the war meant the operation must provide maximum damage to military targets within the shortest time frame possible. Second, Linebacker II concentrated on bombing targets located in the military-industrial center of North Vietnam versus the purpose of Linebacker I of providing widespread interdiction. Linebacker II was 11 days of intense bombing, and within 3 days peace talks were renewed (13:34-34 to 34-35).

Prior to Linebacker II, the North Vietnamese were intransigent, buying time, refusing even to discuss a formal meeting schedule. After Linebacker II, they were shaken, demoralized, anxious to talk about anything. They finally

realized they were at war with a superpower. If there was bewilderment, it was with our reluctance to use that power earlier (18:34-35).

Appendix C: Red Flag

With the conclusion of the Vietnam conflict, HQ USAF and IAC knew that some form of realistic training would be necessary to maintain the combat proficiency of aircrews, both new and experienced.

Headquarters USAF, Tactics Division, formulated the concepts of a realistic training program they called Red Flag. In mid 1975, the TAC/CC was tasked by the AF Chief of Staff to develop, validate, and implement the Red Flag concept (19:9).

Nellis Air Force Base (AFB), Nevada was selected as the site for the program, and the Tactical Fighter Weapons Center (TFWC) was given the management task of the program

The Red Flag program consists of Blue (friendly) forces and Red (threat) forces under a single manager (TFWC) to provide continuous combat training for squadron size forces. The Blue forces are the actual units deployed to Red Flag, and differ for each exercise. The Red forces are broken into ground threats and air threats. The ground threats consists of anti-aircraft artillery (AAA), surface-to-air missiles (SAM), radars and electronic warfare (EW) equipment, all under the control of the Nellis Range Group. Another part of the ground threat is a collection of realistic targets like plywood or polyurethane tanks, trucks, airfields with derelict F-84's, trains, and an effective Warsaw Pact-style air-defense environment. The air threat is provided by the Aggressors, a unit located at Nellis, flying Northrop F-5s to simulate the small minimum-radar MiG-21. The Aggressor squadron uses

the most recent known tactics and doctrine of the Warsaw Pact nations (15:40). An additional part of the Red Flag staff is the White (neutral) forces, who act as evaluators and umpires during each exercise.

The goal is aircrew survival beyond the critical, high-loss rate first ten missions of a war, taking into account that fewer than a quarter of TAC's aircrews have flown in combat. The objective is to save aircrews and airframes by skilled performance earned through an intense, realistic training program (15:40).

While Red Flag tries to simulate and remove those dangerous first 10 missions, it is also designed to help overcome the quantitative advantage of Warsaw Pact aircraft through superior training. Pilots come to Red Flag after they have learned basic weapons skills. Red Flag makes them put all the skills they learned together, in the most realistic training possible. "Red Flag is something more than a training exercise - it's the next best thing to actual combat" (8:3). Red Flag, as controlled by TAC, is a joint exercise to put the final polish on the aircrews and units skills (2:34).

When pilots arrive at Red Flag, they quickly believe a war is on. The ramp at Nellis AFB looks like a combat zone crowded with fighters, rescue helicopters, gunships, and bombers. Intelligence briefings lay out the war scenario, while all briefings stress the paramount importance of safety. The true benefit of Red Flag is the result.

For the 'old heads,' it brings back unpleasant memories of excursions to Hanoi and Haiphong. For the 'new guys,' it's a hair-raising introduction to a classic situation - 'Hey, they're shooting at me!' It's called Red Flag, the closest thing to a wartime environment (8:3).

Appendix D: Possible Composite Fighter Wing Engine Shops
By Aircraft/Engine Combinations

: Type Aircraft/Engine (by number of squadrons) :									
: A-10 : F-16 : F-15 :									
: F34 : F100-200 : F100-220 : F110 : F100-100 : F100-220 :									
Composite Wing type	Close Air	3							
	Support	2	1						
		2		1					
		2			1				
Composite Wing type	Interdiction		2				1		
			2					1	1
				2					1
					2		1		1
Composite Wing type	Counter Air		1				2		2
			1					2	2
					1				2
					1		2		2

Appendix E: Computations for Facility Size Requirements
Based on A Single Squadron

All computations are based on the formula specified in AFM 86-2 (11). The formula and definitions are repeated in Chapter IV. The correct facility size for an engine shop can be determined by using the following formula:

$$\text{Shop Space Authorized} = A \times B \times C \times D / E \quad (1)$$

Where,

A = Support Space from Table 8-3, AFM 86-2

B = Base Repair Cycle time from Table 4-1, T.O. 2-1-18

C = 1/2 number of installed engines for the authorized aircraft

D = Engine work space, 2 X engine length X 4 X engine width, or
use Table 8-3, AFM 86-2

E = Average number of work days per month, which is 22

The actual numbers for each variable by each aircraft/engine type are listed below. Since both the A-10 and F-15 are dual engine aircraft, variable C is equal to 24, the number of aircraft in a squadron for those aircraft, while for the F-16 variable C is equal to 12, which is half the number of aircraft in a squadron. The adjustment factor for other than 72 aircraft configurations have not been included for the F100 engines.

Aircraft/Engine	One Squadron		Variable				TOTAL
	A	B	C	D	E		
A-10							
TF34-GE-100	1.4	17	24	396	22		10,281.5
F-15							
F100-PW-100	2.3	16	24	515	22		20,674.91
F100-PW-220	2.3	9	24	515	22		11,529.54
F-16							
F100-PW-200	3.3	16	12	515	22		14,332
F100-PW-220	3.3	9	12	515	22		3,343
F110-GE-100	3.3	9	12	515	22		3,343

This information can be placed in similar formats for two squadrons (48 aircraft) and three squadrons (72 aircraft) by changing only variable C (number of installed engines). This produces the correct facility size for that particular engine shop. Again, the adjustment factors for the F100 engines have not been included.

		Two Squadrons					
Aircraft/Engine				Variable			
		A	B	C	D	E	TOTAL
A-10							
	TF34-GE-100	1.4	17	48	396	22	20,563.2
F-15							
	F100-PW-100	2.3	16	48	515	22	41,349.82
	F100-PW-220	2.3	9	48	515	22	23,259.27
F-16							
	F100-PW-200	3.3	16	24	515	22	29,664
	F100-PW-220	3.3	9	24	515	22	16,536
	F110-GE-100	3.3	9	24	515	22	16,536

Three Squadrons

Aircraft/Engine	Variable					TOTAL
	A	B	C	D	E	
A-10						
F34-GE-100	1.4	17	72	396	22	30,844.8
F-15						
F100-PW-100	2.3	16	72	515	22	62,024.73
F100-PW-220	2.3	9	72	515	22	34,388.91
F-16						
F100-PW-200	3.3	15	36	515	22	44,496
F100-PW-220	3.3	9	36	515	22	25,029
F110-GE-100	3.3	9	36	515	22	25,029

Actual figures for variables A (support space) and B (base repair cycle) have not been determined for the F100-PW-220 or F110-GE-100 engines (10:4-2). Because of this, the original F100-PW-100/200 figures are used (9; 22). Recently, new base repair cycle times for the F100-PW-100/200 have been determined. This increased variable B from 9 to 16 for these engines (5; 22). This has greatly increased the facility size requirements for these engines. Because of that increase, the numbers may not reflect true requirements as they currently exist.

Appendix F: Total Engine Shop Size Requirements for
Composite Fighter Wings

By taking the square footage figures from appendix E and the squadron make-up from Table 3 and by applying the adjustment factor (discussed in Chapter IV) against the F100 engines, the following figures and computations result:

Close Air Support:

Three A-10 squadrons with TF34-GE-100 engines
 $3 \times 10,281.6 = 30,844.80$

Two A-10 squadrons with TF34-GE-100 engines and one
F-16 squadron with F100-PW-200 engines:
 $20,563.2 + (1.3 \times 14,832) = 39,844.8$

Two A-10 squadrons with TF34-GE-100 engines and one
F-16 squadron with F100-PW-220:
 $20,563.2 + (1.3 \times 8,343) = 31,409.1$

Two A-10 squadrons with TF34-GE-100 engines and one
F-16 squadron with F110-GE-100:
 $20,563.2 + 8,343 = 28,906.2$

Interdiction:

One F-15 squadron with F100-PW-100 engines and Two
F-16 squadrons with F100-PW-200 engines:
 $(1.3 \times 20,674.91) + (1.3 \times 29,664) = 65,440.53$

One F-15 squadron with F100-PW-100 engines and Two
F-16 squadrons with F100-PW-220:
 $(1.3 \times 20,674.91) + (1.3 \times 16,686) = 48,569.18$

One F-15 squadron with F100-PW-100 engines and Two
F-16 squadrons with F110-GE-100 engines:
 $(1.3 \times 20,674.91) + 16,686 = 43,563.38$

One F-15 squadron with F100-PW-220 engines and Two
F-16 squadrons with
F100-PW-200 engines:
 $(1.3 \times 11,629.64) + (1.3 \times 29,664) = 33,503.2$

One F-15 squadron with F100-PW-220 engines and Two
F-16 squadrons with F100-PW-220:
 $(1.3 \times 11,629.64) + (1.3 \times 16,686) = 36,810.33$

One F-15 squadron with F100-PW-220 engines and Two
F-16 squadrons with F110-GE-100 engines:
 $(1.3 \times 11,629.64) + 16,686 = 31,804.53$

Counter Air:

Two F-15 squadrons with F100-PW-100 engines and one
F-16 squadron with F100-PW-200 engines:
 $(1.3 \times 41,349.82) + (1.3 \times 14,832) = 73,036.36$

Two F-15 squadrons with F100-PW-100 engines and one
F-16 squadron with F100-PW-220:
 $(1.3 \times 41,349.82) + (1.3 \times 8,343) = 64,600.66$

Two F-15 squadrons with F100-PW-100 engines and one
F-16 squadron with F110-GE-100 squadrons:
 $(1.3 \times 41,349.82) + 8,343 = 62,097.77$

Two F-15 squadrons with F100-PW-220 engines and one
F-16 squadron with F100-PW-200 engines:
 $(1.3 \times 23,259.28) + (1.3 \times 14,832) = 49,513.67$

Two F-15 squadrons with F100-PW-220 engines and one
F-16 squadron with F100-PW-220:
 $(1.3 \times 23,259.28) + (1.3 \times 8,343) = 41,082.97$

Two F-15 squadrons with F100-PW-220 engines and one
F-16 squadron with F110-GE-100 engines:
 $(1.3 \times 23,259.28) + 8,343 = 38,580.06$

Appendix G: Detailed Manpower Requirements

This appendix shows detailed data on the breakdown of manpower requirements for each type of engine at the three different unit sizes. Although the data shows flightline personnel requirements within each area, they are not added in as part of the total requirement computed for that engine. They are included as possible assistance to help further research into this topic. Manpower is broken down by aircraft/engine and is for one, two, or three squadrons of aircraft.

A-10 TF34-GE-100

Area	1 squadron	2 squadrons	3 squadrons
JEIM shop	24	48	67
Test Cell	6	9	12
Inspection	4	5	6
Flightline	13	26	39
Total	<u>34</u>	<u>62</u>	<u>85</u>

F-15 F100-PW-100

Area	1 squadron	2 squadrons	3 squadrons
JEIM shop	27	48	75
Test cell	6	6	12
Sound Suppressor	6	6	12
Inspection	5	9	14
Flightline	26	52	78
Total	<u>44</u>	<u>69</u>	<u>113</u>

F-15 F100-PW-220

Area	1 squadron	2 squadrons	3 squadrons
JEIM shop	18	30	48
Test cell	6	6	12
Sound Suppressor	6	6	12
Inspection	5	9	14
Flightline	12	24	36
Total	<u>35</u>	<u>51</u>	<u>86</u>

F-16 F100-PW-200

Area	1 squadron	2 squadrons	3 squadrons
JEIM shop	15	25	40
Test cell	8	8	16
Sound Suppressor	8	8	16
Inspection	6	9	15
Flightline	16	32	48
Total	<u>37</u>	<u>50</u>	<u>87</u>

F-16 F100-PW-220

Area	1 squadron	2 squadrons	3 squadrons
JEIM shop	12	16	28
Test cell	8	8	16
Sound Suppressor	8	8	16
Inspection	6	9	15
Flightline	10	20	30
Total	<u>34</u>	<u>41</u>	<u>75</u>

F-16 F110-GE-100

Area	1 squadron	2 squadrons	3 squadrons
JEIM shop	12	18	30
Test cell	8	8	16
Sound Suppressor	8	3	16
Inspection	6	9	15
Flightline	10	20	30
Total	<u>34</u>	<u>43</u>	<u>77</u>

Appendix H: Total Manpower Requirements For
Composite Fighter Wings

This appendix shows how total manpower requirements were computed. First, the requirements for each type of aircraft/engine combination as listed in table 7 or Appendix G with the correct number of squadrons was determined. Then, the appropriate numbers for each composite fighter wing type were placed together and then added. The sum became the total engine shop personnel manpower requirement for that composite fighter wing type. The calculations below detail this process.

Aircraft/engine		Requirement
Close Air Support		
1.	3 A-10 squadrons	85
	Total	<u>85</u>
2.	2 A-10 squadrons	62
	1 F-16 squadron (F100-PW-200)	37
	Total	<u>99</u>
3.	2 A-10 squadrons	62
	1 F-16 squadron (F100-PW-220)	34
	Total	<u>96</u>
4.	2 A-10 squadrons	62
	1 F-16 squadron (F110-GE-100)	34
	Total	<u>96</u>

Interdiction

1.	2 F-16 squadrons (F100-PW-200)	50
	1 F-15 squadron (F100-PW-100)	44
	Total	<u>94</u>
2.	2 F-16 squadrons (F100-PW-220)	41
	1 F-15 squadron (F100-PW-100)	44
	Total	<u>85</u>
3.	2 F-16 squadrons (F110-GE-100)	43
	1 F-15 squadron (F100-PW-100)	44
	Total	<u>87</u>
4.	2 F-16 squadrons (F100-PW-200)	50
	1 F-15 squadron (F100-PW-220)	35
	Total	<u>85</u>
5.	2 F-16 squadrons (F100-PW-220)	41
	1 F-15 squadron (F100-PW-220)	35
	Total	<u>76</u>
6.	2 F-16 squadrons (F110-GE-100)	43
	1 F-15 squadron (F100-PW-220)	35
	Total	<u>78</u>

Counter Air

1.	2 F-15 squadrons (F100-PW-100)	69
	1 F-16 squadron (F100-PW-200)	37
	Total	<u>106</u>
2.	2 F-15 squadrons (F100-PW-100)	69
	1 F-16 squadron (F100-PW-220)	34
	Total	<u>103</u>
3.	2 F-15 squadrons (F100-PW-100)	69
	1 F-16 squadron (F110-GE-100)	34
	Total	<u>103</u>

4.	2 F-15 squadrons (F100-PW-220)	51
	1 F-16 squadron (F100-PW-200)	37

	Total	<u>88</u>
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5.	2 F-15 squadrons (F100-PW-220)	51
	1 F-16 squadron (F100-PW-220)	34

	Total	<u>85</u>
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6.	2 F-15 squadrons (F100-PW-220)	51
	1 F-16 squadron (F110-GE-100)	34

	Total	<u>85</u>
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VIFA

Captain Paul A. Davidson was born on 18 July 1955 in Fort Worth TX. He graduated from Highland High School in Albuquerque NM, in 1973 and attended the University of New Mexico from which he received the degree of Bachelor of Arts in Economics in May 1977. Upon graduation, he recieved a commission in the USAF through the ROTC program, where he was a Distinguished Graduate. He was called to active duty in October 1977. He completed Aircraft Maintenance Officer school at Chanute AFB IL in April 1978. He served in several maintenance positions at the 56th TFW MacDill AFB FL, until October 1980 when he was transferred to the 27th TFW Cannon AFB NM. At Cannon AFB, he was the Officer In Charge of the 523rd and then the 522nd F-111D Aircraft Maintenance Units. While at Cannon AFB, he attended SOS at Maxwell AFB during the summer of 1983. Captain Davidson was next assigned to HQ TAC at Langley AFB VA in January 1984 where he was assigned as Chief of the F100 Propulsion Branch. He served in this position until he entered the School of Systems and Logistics, Air Force Institute of Technology, in June 1986.

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This study focused on the requirements for an engine shop under a composite fighter wing structure. The composite fighter wing structure was proposed to provide Tactical Air Forces the capability to better meet the challenge of low intensity conflicts and to provide increased aircraft survivability. The proposal called for use of three basic wings: Close Air Support, made up of A-10s and F-16s; Interdiction, made up of F-16s and F-15s; and Counter Air, also made up of F-16s and F-15s.

This study looked specifically at engine shop facility sizes, engine test facilities, and engine shop manpower needs. All computations were based on current facility size measurement data, test facility needs, and manpower authorizations. This information was used to calculate the engine shop requirements for each type of composite fighter wing engine shop.

The study revealed that a Close Air Support Wing would require a facility of 23,906 - 39,345 square feet, 3 - 4 engine test facilities, and 85 - 99 engine shop repair personnel. An Interdiction Wing required a facility 31,305 - 65,441 square feet, 3 - 4 test facilities, and 76 - 94 personnel. The Counter Air Wing would need 38,530 - 73,036 square feet of facility space, 3 - 4 test facilities, and 35 - 106 personnel.

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